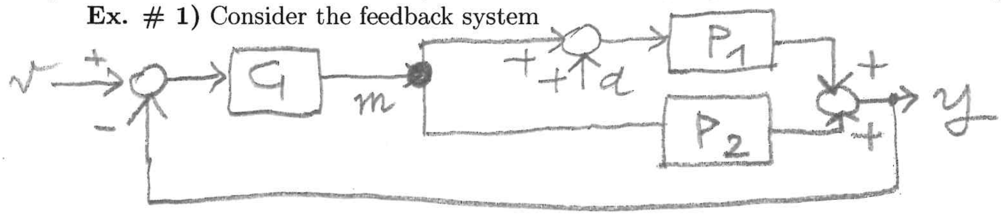
CONTROL SYSTEMS - 1/6/2021

[time 2 hours and 30 minutes; no textbooks; no programmable calculators]

Ex. # 1) Consider the feedback system



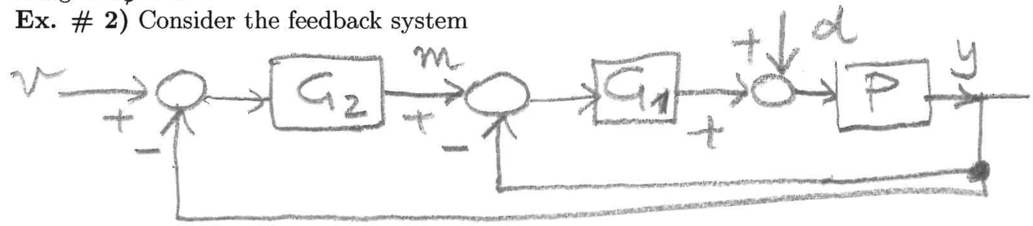
with $\mathbf{P}_1(s) = \frac{1}{s^2}$ and $\mathbf{P}_2(s) = \frac{1}{s^3}$. Design minimal dimensional $\mathbf{G}(s)$ such that

(i) the closed-loop system is asymptotically stable (use Nyquist criterion) with steady-state output response $\mathbf{y}_{ss}(t) \equiv 0$ to constant disturbances $\mathbf{d}(t)$,

(ii) $|\mathbf{G}(j\omega)| \leqslant 36$ dB for all ω,

(iii) the open loop system has crossover frequency $\omega_t \geqslant 5$ rad/sec and phase margin $m_\varphi \geqslant 30°$.

Ex. # 2) Consider the feedback system



with $\mathbf{P}(s) = \frac{1}{s-2}$. Design minimal dimensional controllers $\mathbf{G}_1(s)$ and $\mathbf{G}_2(s)$ in such a way that the closed-loop system is asymptotically stable with steady-state output response $\mathbf{y}_{ss}(t) \equiv 0$ to disturbances $\mathbf{d}(t) = t$. Draw the root locus of the open loop system $\frac{\mathbf{G}_2\mathbf{G}_1\mathbf{P}}{1+\mathbf{G}_1\mathbf{P}}$ using the Routh table for an accurate study of the intersections with the imaginary axis.

Ex. # 3) If the forced output response $\mathbf{y}(t)$ of a given system to a step input $\mathbf{v}(t) = \delta^{(-1)}(t)$ is

$$\mathbf{y}(t) = 1 - e^{-t}(1+t) - e^{-3t}$$

(i) determine the I/O transfer function $\mathbf{P}(s)$ of the system

(ii) determine a state space realization of $\mathbf{P}(s)$

(iii) determine (approximately) the 5%-settling time